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Parametric Evaluation Performance of Ti-6Al-4V using Coated & Uncoated Carbide Insert in CNC Turning - A Review

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Abstract: This study consists a comparison of outcomes obtained by PVD coated carbide insert and uncoated carbide insert during dry turning Ti6Al4V which is titanium alloy. It has many applications such as aerospace components, medical surgical parts etc. due to their properties such as high strength to weight ratio, better corrosion resistance and heat treatable. In this experiment, turning was carried out using different cutting parameters like speed, feed and depth of cut. Design of Experiment was based on Taguchi's L9 orthogonal array. Surface roughness was measured for different combination of input parameter. The analysis of variance is carried out to get the optimal levels and to analyze the effect of the cutting parameters on the surface roughness with different inserts of tools.

Key words: Titanium alloy, Dry machining, Taguchi method, PVD Coated, Uncoated carbide Insert

I. INTRODUCTION

In recent years, Because of the extreme working environment of aviation engines the improvement of aircraft engines has been done which depends on the properties of materials. Among all the choices, titanium alloy has become one of the most favorable materials in the aerospace industry. It has very high strength-to-weight ratio which makes titanium alloy a lightweight material with high strength. In addition to that it has high strength at elevated temperatures, a property that enables it to stand the aircraft engine environment. However, titanium is classified as a difficult-to-cut material because of its several inherent properties like its low thermal conductivity increases the temperature at the tool and work-piece interface, which affects tool performance dramatically. The second, its high chemical reactivity causes problems of material bonding and chip evacuation, which commonly leads to severe tool failure. Finally, its high strength at elevated temperatures, although it has been mentioned above as one advantage, requires extremely large cutting forces and power, which leads to several difficulties during the machining process. Thus, the machining of titanium alloy has become an important issue in both industrial and academic field.

Turning is considered a critical process not only because it can remove the unwanted part of materials efficiently, but also because it can create almost all kinds of contour surfaces smoothly. However it is a cutting process with varying chip load, forces and heat generation. Along the turning tool edges, the rake and clearance angles vary with respect to the distance from the milling tool tip. Therefore, the analysis of turning process and turning tool performance is always a big challenge.

Turning titanium alloys has drawn attention because the material is difficult to cut or the available speed is low. A large amount of heat generated during the cutting process conducts to the tool instead of the chips or work-piece due to the low thermal conductivity of titanium alloys. The high temperature in the tool degrades the tool properties and results in thermal stress and causes excessive damage to the tool. Experimental approach is still the dominant method to investigate the tool performance in titanium turning process numerous studies focused on testing for different cutting conditions.

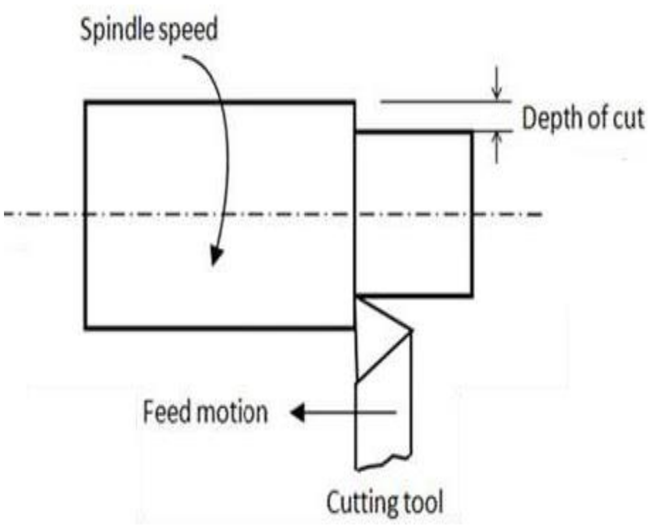

Fig. 1: Turning Process

II. CNC TURNING PROCESS

Turning is defined as the process of removing material from the outer diameter of the work-piece. In this process, the single point cutting tool is moving parallel to rotating axis with a certain velocity. It is used to produces work-pieces with conical, curved, or grooved shapes. The turning process is illustrated in fig 2.

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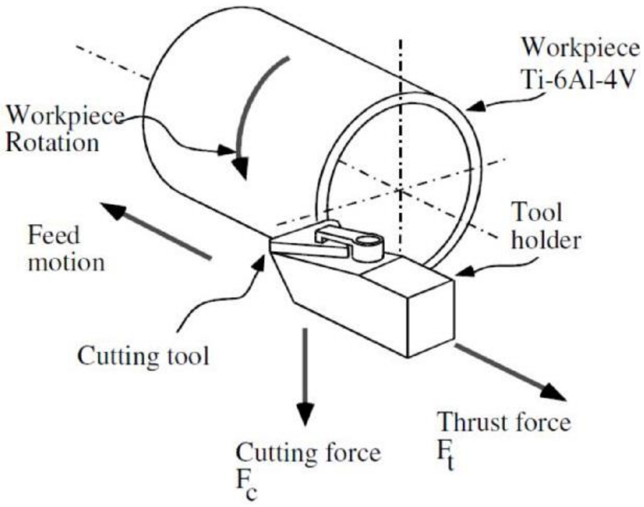

Fig. 2: Forces Acting in Turning Process

The Automatic turning process is carried out on CNC Lathe machine. The cutting parameters of the operation include the speed, feed and depth of cut. The selection of these parameters influences cutting forces, power consumption, and surface roughness of the work-piece and cutting tool life. Cutting parameters are usually selected based on the work-piece material, tool material, and tool geometry. Optimization of cutting conditions will minimize the machining cost and improve the quality of the product.

Figure 2 shows the three forces acting on the cutting tool in the turning process. The cutting force (Fc) is main force in the turning process and it acts downward on the cutting tool. The thrust force (Ft) or feed force acts in the direction of the feed motion of the cutting tool. The radial force (Fr) acts in the radial direction

III. LITERATURE REVIEW

Many researchers have studied the performance of titanium alloy Gr. 5 (Ti6Al4V) under various cutting parameter and methodology.

Cutting Force Analysis and Performance of PVD coated tungsten carbide When Milling of Ti6Al4V under MQL had been conducted by Ahmad Yasir M.S. He discussed an experimental investigation on the variation of cutting force in end milling of Ti6Al4V using PVD coated tungsten carbide under MQL. The variation of cutting force was investigated at various cutting condition. Completely dry machining and near dry (MQL) were applied in this experiment. For near dry machining, two levels of coolant flow rate were investigated, 50 and 100 mL/H. The effectiveness of mist coolant in order to reduce cutting force was tested at three different levels of cutting speed, 120, 135 and 150 m/min. The performance of cutting tools was measured by the tool life. The DOE for the cutting force and tool life were performed by using MiniTab software. Effect of coolant on cutting force seems to be varied depend on the coolant flow rate and cutting speed. However cutting force is more sensitive to the feed rate and depth of cut. In term of tool life, application of mist coolant is more significant at cutting speed of 135 m/min. At this speed longer tool life was obtained. [1] Rajendra Pawar concluded that higher compressive residual stresses are produced when the highest cutting speed, and lowest federate and moderate depth of cut. These machining conditions promote mechanically dominated deformation during machining. The micro hardness of machined subsurface at a depth varies between 365 & 395 as compared to its bulk counterpart 338 to 360. Further, it is possible to arrive at the depth of machining deformed layer. The statistical analysis of degree of work hardening beneath the machined surface shows that the depth of cut and the interaction between feedrate and depth of cut have the most significant effects on the degree of work hardening. [2] A study on a comparison of surface roughness obtained by coated carbide inserts and uncoated carbide inserts during dry turning of titanium alloy had been conducted by Digvijay K. Patil. He also added that Titanium alloy has many applications such as engine valves, connecting rod, suspension springs, airframe components, etc. due to their properties such as high strength to weight ratio, heat treatable and better corrosion resistance. In this experimental work turning on titanium alloy with different cutting parameters like cutting speed, feed and depth of cut has been carried out. Experimentation was carried out using Taguchi’s L9 orthogonal array. Surface roughness was measured for each experimentation. Parameters were optimized and analysis of variance (ANOVA) was carried out. The assessment gives that, when compared to uncoated carbide inserts, the coated carbide inserts shows significantly improved surface roughness. [3]

Analysis of Lubrication Strategies for Sustainable Machining during Turning of Titanium Ti6AlV alloy had been conducted by Ibrahim Deiab. The current drive for achieving the implementation of sustainability concepts in manufacturing calls for sustainable machining practices to be adopted. A key area of research is the search for environmentally benign cooling strategies. Vegetable oils have often been proposed as sustainable alternatives to the conventional synthetic emulsion coolants. Techniques like dry and cryogenic machining, minimum quantity lubrication (MQL) and minimum quantity cooled lubrication (MQCL) have also been proposed. The current study investigates the effect of six different strategies on the flank tool wear, surface roughness and energy consumption during turning of titanium Ti-6Al-4V using uncoated carbide tool at certain speed and feed. The use of rapeseed vegetable oil in MQL and MQCL configuration turns out to be an overall sustainable alternative. Thus confirming the promise predicted in the use of vegetable oil as a lubricant for machining. [4] Taguchi Method is the approach to optimize the process parameters for improving the quality of components manufactured. The objective of the study is to illustrate the procedure adopted in Taguchi Method for lathe facing operation. The orthogonal array, signal-to-noise ratio, and the analysis of variance are employed to study the performance characteristics of the operation. In the analysis, A suitable orthogonal array of three factors namely speed; feed and depth of cut was selected and experiments were conducted. Then the surface roughness was measured and Signal to Noise ratio was calculated. With the help of graphs, optimum parameter values were obtained and the confirmation experiments were carried out. These results were compared with the results of full factorial method. This paper illustrates the application of the parameter design (Taguchi method) in the optimization of facing operation.

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It is found that the parameter design of the Taguchi method provides a simple, systematic, and efficient methodology for optimizing the process parameters. [5]

A study on Tool Wear Performance of CVD-Insert during Machining of Ti6Al4V ELI at High Cutting Speed had been done by Gusri Akhyar Ibrahim. Machining of titanium alloys as aerospace material that has extremely strength to weight ratio and resistant to corrosion at high-elevated temperature, become more interested topic. However, titanium alloys have low thermal conductivity, relative low modulus elasticity and high chemical reactivity with many cutting tool materials. The turning parameters evaluated are cutting speed (55, 75, 95 m/min), feed rate (0.15, 0.25, 0.35 mm/rev), depth of cut (0.10, 0.15, 0.20 and tool grade of CVD carbide tool. The result that pattern of tool life progression is rapidly increased at the initial stage. It was due to small contact area between the cutting tool and the work piece. At the first step of machining, the chip welded at the cutting edge but some chip removed away from the cutting edge. Wear mechanism produced are abrasive wear, adhesive, flaking, chipping at the cutting edge and coating delaminating. [6]

IV. CONCLUSION

From the above literature survey it is observed that most of the researcher has taken input parameters (controllable factors): cutting speed, feed rate and depth of cut and output parameters: Cutting force, surface roughness, material removal rate (MRR), tool wear, average flank wear, mach inability. It is also found that only few researchers have taken both inserts i.e. Coated & Uncoated. This paper represents the effect of turning parameter on obtained Surface Roughness as follow:

The PVD coated carbide insert shows better performance compared with uncoated carbide insert in terms of surface roughness of work piece.

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